# REDUCING GREENHOUSE GAS EMISSIONS FROM PRODUCTS MANUFACTURED IN CALIFORNIA


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**Second Annual Climate Change Research Conference**
**Sacramento, CA**
**September 14th, 2005**

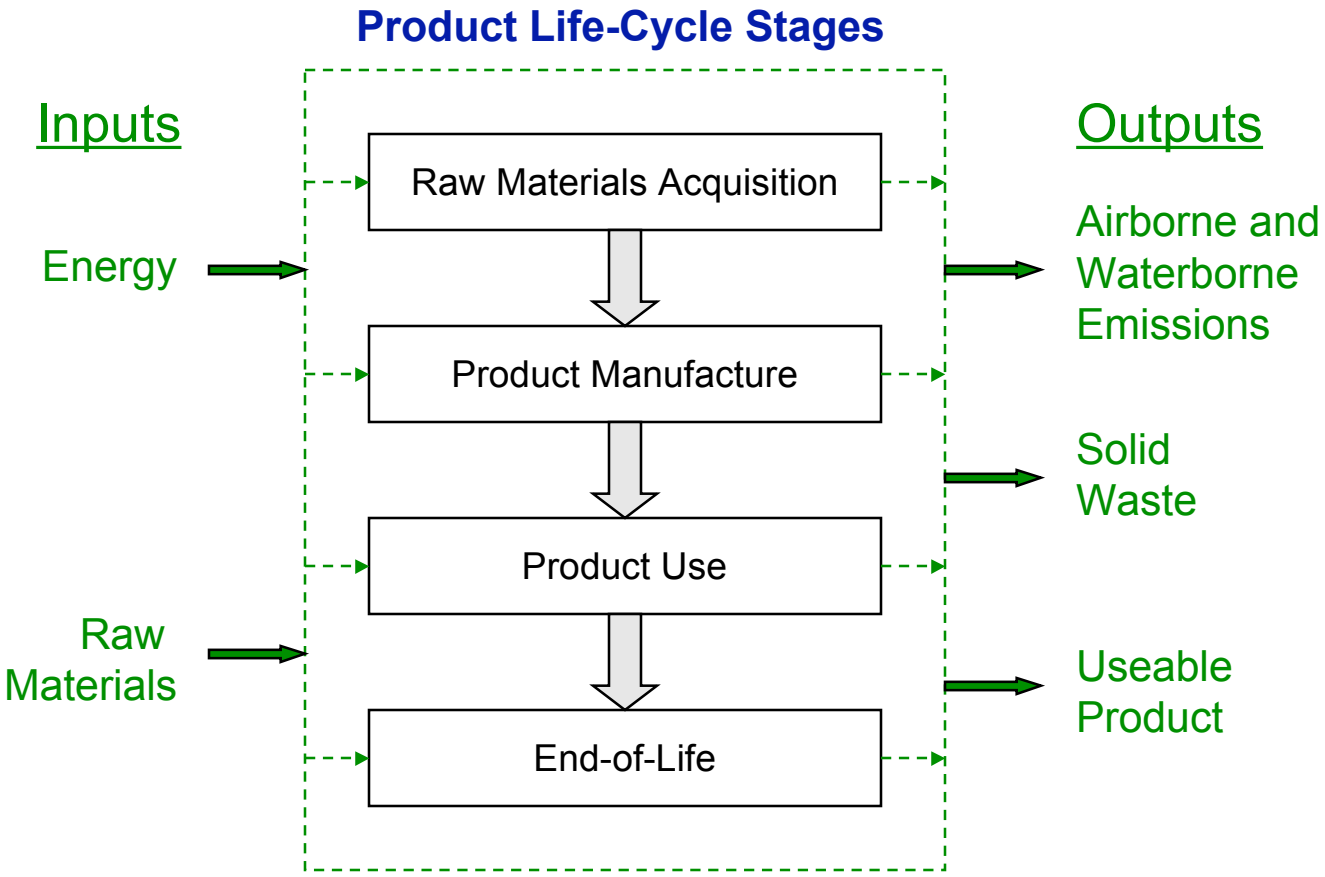
# Lawrence Berkeley National Laboratory (LBNL)

- U.S. Department of Energy research laboratory
- Managed by the University of California
- 4000 employees
  - 200 UC faculty
  - 600 graduate students
  - 90 post doc fellows
  - many visiting foreign researchers
- 10 Nobel Laureates

# Project sponsor

- **California Energy Commission Public Interest Energy Research (PIER) Program**
- **Environmental Exploratory Grant Program**
- **Program goal:** "to support the early development of promising, new scientific concepts with the potential to impact the way we understand and/or address energy-related environmental issues"
- Grant awarded to LBNL for "***Optimization of Product Life Cycles to Reduce Greenhouse Gas Emissions***" in 2003

# Product life-cycle optimization




**Product Life-Cycle Assessment (LCA)**

# Project goals

1) Estimate the life-cycle GHG emissions of 50 major California-manufactured products

2) Perform detailed LCA for two case studies (personal computers, cement and concrete)

3) Identify and quantify GHG mitigation opportunities at each life-cycle stage for the two case study products

4) Suggest policy opportunities for California to implement the proposed GHG mitigation measures

**Scope of presentation**

# Why a life-cycle approach?

- **Provides a systems perspective in product environmental assessment**
  - **Prevents "shifting" of environmental burdens**
  - **Provides comprehensive environmental assessment (energy, GHGs, air pollution, solid waste)**
- **Supports an Integrated Product Policy (IPP) approach toward energy efficiency**
  - **Green procurement is key component of IPP**
- **Detailed approach may uncover previously-unknown environmental concerns associated with a product**

# Personal computers (PCs)

## Manufacturing

- 169 million PCs were manufactured globally in 2003
- California's role in global PC manufacturing:
  - Computer assembly
  - Semiconductor chips
  - Electronic components
- California's "hi tech" sector employs over 700,000 people

*Courtesy of Apple*

## Use

- An estimated 16 million PCs were currently installed in California homes and businesses in 2001, more than any other U.S. state

## End-of-Life

- An estimated 10,000 PCs become obsolete in California every day

# PC life-cycle GHG emissions

## Estimated Life-Cycle Emissions

| Life-Cycle Stage | Primary Energy | Estimated California GHG Emissions | |
|---|---|---|---|
| | PJ/yr | Mt $CO_2e$/yr | Equivalent Autos* |
| Manufacturing | 54.3 | 4.18 | 923,000 |
| Use | 39.4 | 1.72 | 380,000 |
| End-of-Life | 0.05 | 0.004 | 1,000 |
| **Total** | **93.7** | **5.90** | **1,300,000** |

* assumes the average automobile in California emits 4,500 kg $CO_2$/yr.

- Estimated production energy is 2.7% of 2001 primary energy consumed by California's industrial sector
- Estimated use energy is 1.7% of 2001 primary electrical energy consumed by California's residential and commercial sectors
- Total estimated life-cycle GHG emissions are 1.5% of California's 1999 statewide net GHG emissions

# PC case study: measures identified

## Summary of Potential Measures and GHG Reductions

| Life-Cycle Stage | Measure | Estimated Technical Potential for Life-Cycle GHG Emission Reduction in California | | |
|---|---|---|---|---|
| | | Mt $CO_2$e/yr | %* | Equivalent Autos |
| Manufacturing | Improve clean room energy efficiency | 0.72 | 12% | 160,000 |
| | Reduce PFC emissions of semiconductor manufacture | 0.26 | 4% | 58,000 |
| Use | Maximize PC power management utilization | 0.47 | 8% | 105,000 |
| | Switch from CRT monitors to LCDs | 0.48 | 8% | 105,000 |
| | Maximize the energy efficiency of California's PCs | 0.10 | 2% | 22,000 |
| End-of-Life | Upgrade California's PCs to extend their useful life | 0.018 | <1% | 4,000 |
| | Maximize PC control unit recycling in California | 0.11 | 2% | 24,000 |

* % reduction with respect to California total PC life-cycle GHG emissions of 5.9 Mt $CO_2$e/yr.

**Total estimated technical potential of GHG reductions is over 2 Mt $CO_2$e/yr (~0.5% of California's 1999 statewide net GHG emissions)**

# Policy opportunities for California

- **Adoption and promotion of green procurement policies for PCs**
  - Large institutional buyers could give preferential buying status for:
    - Certification to the most stringent Energy Star standard
    - Eco-label eco-design certification (e.g., TCO 99, Blue Angel, EU Eco Flower)
    - LCDs instead of CRTs
    - PC manufacturers with established “take-back” systems
  - US EPA Electronic Products Environmental Assessment Tool (http://www.epeat.net/)

- **Power management awareness campaigns**
  - Only an estimated 25% of PC control units and 75% of PC displays utilize power management features
  - Awareness campaigns targeting California business PC users (75% of electricity consumed by California PCs) could be particularly effective
  - Promotion of facility “switch off” campaigns

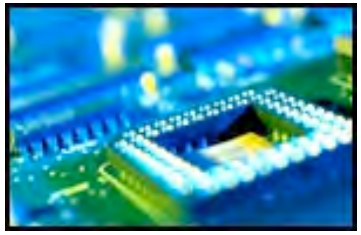

**ENERGY STAR©**

- **Promotion of PC life extension in large organizations**
  - PC upgrading and/or “down-cycling”

# Policy opportunities for California

- **Increased clean room energy efficiency**
  - Improvements to air handling systems, chillers, recirculation fans, and process controls can lead to energy savings of 30-60%
  - Continue to promote energy efficiency progress through increased R&D, energy efficiency targets, and incentives

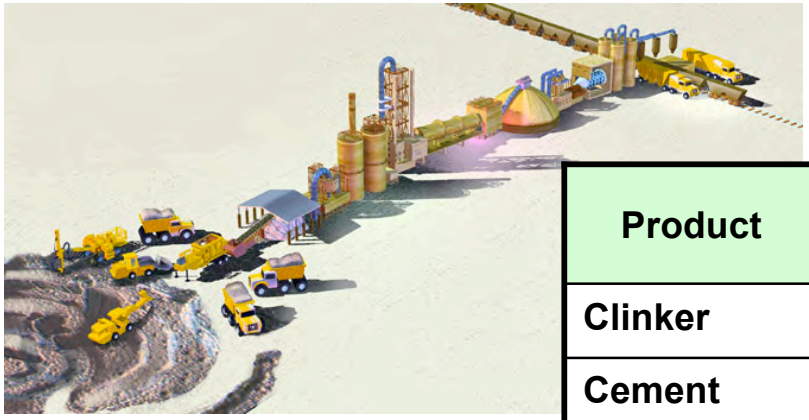
- **Reduction of PFC emissions from semiconductor manufacture**



  - U.S. EPA's voluntary PFC Reduction/Climate Partnership for the Semiconductor Industry aims to reduce U.S. PFC emissions from semiconductor manufacturing to 10% less than 1995 levels by 2010
  - Promote participation by California plants

- **Increase PC control unit recycling in California**
  - Only CRT monitors, notebooks, and LCDs are currently included in California's Electronics Waste Recycling Act of 2003

# Cement and concrete



## Manufacturing

| Product | Production (short tons) | Employees | Value of Shipments |
|---|---|---|---|
| Clinker | 11,187,000 | | |
| Cement | 11,166,000 | 2,000 | $0.8 billion |
| Concrete | 80,000,000 | 16,000 | $2.8 billion |

## Use

- Some studies suggest that concrete highways reduce rolling resistance for heavy trucks, leading to fuel savings
- Insulated concrete houses have a higher thermal mass, which may lead to increased fuel savings over the lifetime of the house

## End-of-Life

- An estimated 400,000 tonnes of demolition concrete are sent to landfills in California each year

# Cement/concrete life-cycle GHG emissions

## Estimated Life-Cycle Emissions

| Life-Cycle Stage | Product | Estimated California GHG Emissions | |
|---|---|---|---|
| | | Mt $CO_2e$/yr | Equivalent Autos |
| Manufacturing | Cement<br>Concrete<br>Total | 10.4<br>1.0<br>11.4 | 2,300,00<br>200,000<br>2,500,00 |
| Use | | - | - |
| End-of-Life | | 0.02 | 50,000 |
| **Total** | | **11.4** | **2,550,000** |

- Total estimated life-cycle GHG emissions are 2.8% of California's 1999 statewide net GHG emissions

# Cement/concrete case study: measures identified

## Summary of Potential Measures and GHG Reductions

| Life-Cycle Stage | Measure | Estimated Technical Potential for Life-Cycle GHG Emission Reduction in California | | |
|---|---|---|---|---|
| | | Mt $CO_2$e/yr | %* | Equivalent Autos |
| **Manufacturing** | Improve energy efficiency in cement manufacture | 0.68 | 6% | 150,000 |
| | Use waste fuels in cement manufacture | 0.62 | 5% | 140,000 |
| | Use blended cement (e.g., fly ash) | 0.55 | 5% | 120,000 |
| | Add limestone to Portland cement | 0.44 | 4% | 100,000 |
| | CemStar® (steel slags) in Portland cement | 0.007 | <1% | 1,500 |
| **Use** | Fuel efficiency heavy trucks | 0.04 | <1% | 9,000 |
| **End-of-Life** | Increase concrete recycling | 0.004 | <1% | 1,000 |

* % reduction with respect to California cement/concrete life-cycle GHG emissions of 11.40 Mt $CO_2$e/yr.

**Total estimated technical potential of GHG reductions is nearly 2 Mt $CO_2$e/yr (~0.5% of California's 1999 statewide net GHG emissions)**

# Policy options for California

- **Procurement and product specifications for changes in cement composition**
  - **Blended cements (fly-ash, blast furnace slag, or other materials)**
    - Change specifications to allow for non-Portland cement (many agencies and constructors mandate Portland cement)
    - City of Berkeley Resolution directing procurement of blended cement for City buildings and other construction (12/2002)
  - **Limestone addition**
    - Portland Cement Association has proposed to change ASTM standard to allow 5% ground limestone in Portland cement (European standards allow 6-35% limestone)

Crews put in a new foundation, made of 50 percent fly ash, at Wurster Hall on the UC Berkeley campus. *Arleen Ng photo*

# Policy options for California

- **Increased energy efficiency improvements in cement manufacture**
  - **Establish energy-efficiency targets or goals**
    - Common practice in many countries
    - Government provides incentives and support in exchange for achievement of targets

**Long-Term Agreements in The Netherlands**
- 29 sectors signed; many met or exceeded targets
- Agreements 22.3% savings over 10-year period
- 2x business-as-usual

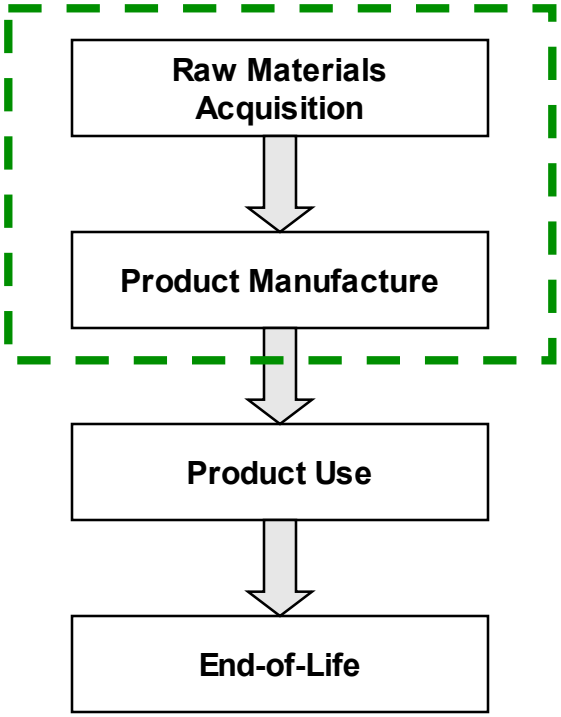
- **Use of alternative or waste-derived fuels**
  - Research and development of information to overcome public concerns about hazardous air pollutants from waste-derived fuels such as tires, rubber, and waste oils,

- **Increased recycling of concrete**
  - Promote the use of recycled concrete as aggregate

# Follow on research

## Development of a California supply chain model to estimate the GHG emissions of California-manufactured products

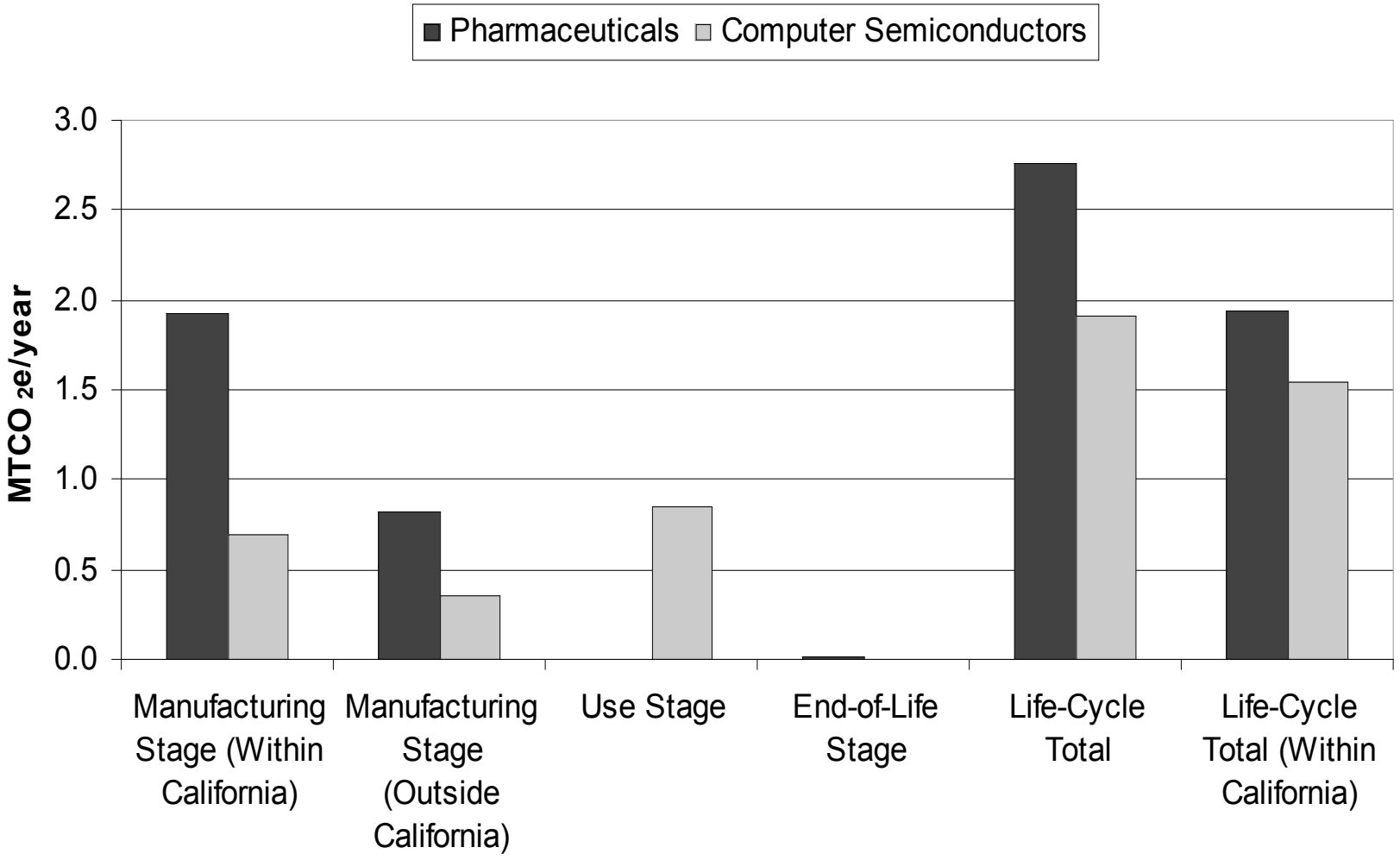
### Modeling Focus




### Modeling Details

- Based on Economic Input-Output LCA (Carnegie Mellon)
- Estimates annual supply chain GHG emissions by industrial sector
- Characterizes in-state and out-of-state GHG emissions
- Facilitates analysis of product design and supply chain improvements

# Case study results




**Life-Cycle GHG Emissions Results**

# Conclusions

- Systematic, life-cycle optimization approach for GHG emissions mitigation in California provides a broader perspective for policy

- GHG mitigation options for PCs and cement/concrete have a technical potential savings of over 4 Mt $CO_2$e/yr, or about 1% of California's 1999 net GHG emissions of 398 Mt $CO_2$

- Such potential savings represent economic waste, energy losses, and pollution – all of which are important to reduce in order to maintain California's position as both an economic and environmental global leader

# For further information

## Project report

Masanet, E., L. Price, S. de la Rue du Can, R. Brown, and E. Worrell. 2005. *Optimization of Product Life Cycles to Reduce Greenhouse Gas Emissions in California*. California Energy Commission, PIER Energy-Related Environmental Research. CEC-500-2005-110-F.

Available online:
http://www.energy.ca.gov/2005publications/CEC-500-2005-110/CEC-500-2005-110-F.PDF

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